Articles

Pregnant Workers
A Physician's Guide to Assessing Safe Employment

JASON S. FEINBERG, MD, *Beaufort, South Carolina, and* CHARLES R. KELLEY, MD, MPH, *Honolulu, Hawaii*

The demographics of the workforce have changed dramatically in recent decades. Today women constitute nearly 50% of the workforce, and most are in their reproductive years. Women are employed in occupations with exposures to strenuous physical exertion, chemicals, ionizing radiation, heat, noise, vibration, infectious agents, and stress. These factors can, in some instances, pose risks to pregnant workers and their developing fetuses. Primary care physicians are at times asked to assess the work environment and the safety of employment during pregnancy. Physicians who evaluate pregnant workers should be aware of the available databases and understand the process for evaluating a possible reproductive risk. Physician certification that a worker is disabled due to pregnancy can result in a substantial financial burden to both employer and employee. In this article, we review pertinent legal and employment issues related to pregnancy, provide clues to obtaining an individual exposure history, identify categories of concern for pregnant workers, and provide an approach to assessing the risk for each of these categories.

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A 28-year-old school teacher in her second trimester of pregnancy saw her physician because she was concerned over a recent viral outbreak among students. She inquired whether this posed a substantial risk to her unborn child. The patient was asymptomatic, and the results of an examination were unrevealing. The physician contacted school officials who reported the outbreak as "slapped cheeks" or erythema infectiosum (fifth disease), which is known to be caused by human parvovirus B19 and transmitted by respiratory droplets. The physician obtained a serum specimen to determine the presence of immunoglobulin M and G antibodies against parvovirus. Tests showed no evidence of acute infection or immune protection from a past exposure.

The physician counseled the patient regarding the possible exposure risk (an increased risk of fetal loss) and recommended that she avoid all contact with school children until the outbreak subsided. Transfer to another job was not possible, and the patient remained off work for two months at reduced pay. The patient was delivered of a healthy boy at 40 weeks' gestation.

Legislative Policies

The job climate has changed dramatically during the past four decades in employee protection from job-related exposures. Initial legislation protected against worker discrimination based on race, color, religion, sex, and national origin and only later included the pregnant worker. Workers' compensation was established to cover injured workers, but fell short of compensating pregnant women for time lost during both normal and complicated pregnancies.

During the late 1970s, fetal protection policies occupied much of the legislative arena and challenged previous discriminatory policies. The following is a brief overview of legislative actions that are pertinent to pregnant workers.

Worker Discrimination

It was not until 1978, through the Pregnancy Discrimination Act,[1] that women were protected from employment discrimination based on pregnancy or fertility status. Title VII of the 1964 Civil Rights Act[2] protected workers from discrimination based on race, color, religion, sex, and national origin. Discrimination based on sex was not well defined and did not include the identifiers "pregnancy, childbirth, or related medical conditions" that were amended to title VII through the Pregnancy Discrimination Act of 1978. Since then, employers are required to treat women affected by "pregnancy, childbirth, or related medical conditions" equally for all employment-related purposes.

From the Department of Internal Medicine, University of California, San Francisco, School of Medicine; the Beaufort Naval Hospital, Beaufort, South Carolina; and the Department of Occupational Medicine, Straub Clinic and Hospital, Honolulu, Hawaii.

Reprint requests to Jason S. Feinberg, MD, 1011 11th St, Port Royal, SC 29935.

Fetal Protection

In 1977 Globe Union, a manufacturer of storage batteries, established a voluntary fetal protection policy pertaining to the occupational exposure of lead. Women workers were informed of concerns about lead exposure and were offered voluntary transfer to jobs without such exposure. In 1978 Johnson Controls purchased Globe Union and in 1982 adopted a new required fetal protection policy. Citing the failure of the voluntary policy, as evidenced by six pregnancies from 1977 to 1982, the new policy excluded all women capable of bearing children from any jobs with exposure to lead. Medical confirmation of the inability to bear children was required for women to work in jobs that exposed them to lead.[3]

The United Automobile, Aerospace, and Agricultural Implement Workers of America (UAW) and others brought suit against Johnson Controls in 1984. The group held that the company's new fetal protection policy discriminated against women by restricting employment on the basis of their fertility status. Second, it held that men were discriminated against because the company failed to provide equal protection against a workplace hazard. US District Judge Robert Warren decided in favor of Johnson Controls in 1988.[4] In 1989 the case of UAW versus Johnson Controls was appealed unsuccessfully to the Seventh Circuit Court.[5] The case was brought to the Supreme Court in 1991, which unanimously reversed the lower courts' decisions, stating that all fetal protection policies are in violation of title VII.[6] Thus, exposure protection policies are held applicable to all workers regardless of pregnancy or fertility status.

Compensation

There are two obvious issues regarding compensation for pregnant workers. First, where does a worker seek compensation if reproductive or fetal injury is thought to have been precipitated by a workplace exposure? Second, is a pregnant worker entitled to compensated disability based on pregnancy alone?

Reproductive harm and injury are generally not covered by workers' compensation.[7] Workers' compensation statutes generally require three conditions for cases to be considered for compensation. The illness or injury must be caused by a workplace injury or accident, must result in job disability, and must be a personal illness or injury. Hence, a worker's spouse, child, or future children are not covered by workers' compensation protection. The only recourse for reproductive injury, including infertility and injury to offspring, is usually through the judicial tort system.[8]

Most states do not mandate paid pregnancy leave. In these states, the issue of paid leave for pregnancy is usually decided by individual employment policies. Such policies often use a worker's sick leave, and compensation may be full or a reduced percentage of the worker's average weekly pay. The duration of benefits tends to vary and generally does not exceed six weeks. The Family and Medical Leave Act of 1993[9] federally mandates that employers grant as much as 90 days of unpaid leave to pregnant workers. It also provides job security, safeguarding a worker's job on her return to employment within 90 days.

In Hawaii and other states, the Temporary Disability Insurance Law applies to pregnant workers and is mandatory. In Hawaii, the current premium cost is $0.80 per $100.00 of wages, which is usually shared between worker and employer. Current reimbursement benefits of the Temporary Disability Insurance Law include as much as 58% of average weekly wages but not more than the maximum weekly benefit ($338 in 1994) set annually by the state's Disability Compensation Division.[10]

Exposure History of Pregnant Women

More patients are asking health care professionals to evaluate possible personal occupational and environmental reproductive hazards. This can be a difficult process for physicians unfamiliar with using a multidisciplinary approach that may include occupational health specialists, toxicologists, and industrial hygienists.[11,12]

Clinical risk assessment on reproductive health requires identifying and quantifying an exposure, determining the timing of an exposure, and synthesizing the known information into an estimated risk.[13] Preconception exposures both to men (through sperm) and to women (through ova) can affect subsequent offspring. Obtaining an accurate and detailed exposure history requires physicians to ask a unique set of questions regarding the occupational and environmental history and is a crucial starting point in making a clinical risk assessment.

The occupational and environmental history should include past and current job titles (including the duration of employment) and descriptions of each job task. Occupational exposures to specific chemicals (smoke, vapors, or dust), infectious agents (viruses), physical elements (exertion, heat, lifting, noise, or irradiation), and psychological features (stress) should be recorded. In addition, physicians should inquire about secondhand smoke in the workplace because many companies have not adopted no-smoking policies.

Physicians should also note any personal protective measures (respirators, masks, or gloves) and physical plant controls (such as ventilation systems) used to prevent exposure. Further, they should attempt to delineate any temporal relationship of existing symptoms to work exposures. The same investigative inquiries can be made regarding community and home exposures. Additional sources of exposure may include hobbies, household products, known water contamination, air pollution, and others.[13]

An individual exposure history of a pregnant woman and women desiring pregnancy should include a review of the medical history, including past pregnancy outcomes. A medication history and the use of alcohol, caffeine-containing beverages, tobacco, or illicit drugs should be recorded because they adversely affect preg-

nancy and fetal development independent of work environment exposures.

Categories of Concern in Reproductive Health

When evaluating a pregnant worker for work-related risks, clinicians are faced with an overwhelming list of possible concerns. The list should be broken down into general categories of concern. We have selected the following categories for review; many others exist (including second-hand smoke in the workplace) and should be investigated as clinically indicated.

Chemicals and Heavy Metals

Exposure to chemicals and heavy metal for a pregnant women is of great concern and heightened awareness. Many chemicals may be associated with birth defects and adverse pregnancy outcomes. Unfortunately, scientific data on human chemical exposure is often retrospective, if available at all. For example, exposures to anesthetic gases,[14–16] ethylene oxide,[17] and lead[18] have been associated with spontaneous abortion. Lead exposure is also linked to low birth weights, minor congenital anomalies, and impaired cognitive development.[19–24] Organic mercury is strongly linked to central nervous system malfunction and cerebropalsy.[25] Comprehensive reviews of chemical exposures, including pesticides and solvents, have been published elsewhere.[13,26–28]

Part of the challenge when assessing the risk posed by exposures to chemicals and heavy metals is that the available data on which to make an informed decision are often hard to obtain, are conflicting, and are difficult to relate to the clinical situation. Of the approximately 60,000 chemical substances currently used in industry, only 3,000 (5%) have been investigated for reproductive effects.[29] When comparing different studies, the results are often inconsistent. Most agents have been studied using animal models that have been shown to be imperfect, hence we must interpolate animal data with caution. For example, the safety of thalidomide was established with the use of rabbits that were retrospectively found to have a tolerance five times that of humans.[29] Until recently, the reproductive end points studied were highly variable and limited to spontaneous abortion, preterm birth, low birth weights, and congenital malformations. Important data often lack the more subtle or long-term adverse developmental outcomes, including cognitive development.

Physicians should define the chemical(s) in question as accurately as possible. Most employees are familiar only with the trade names of the chemicals they work with. To determine the correct scientific name, the employee should be asked to obtain a copy of the "Material Safety and Data Sheet" from the employer, which companies are required to provide. This fact sheet is created by the chemical manufacturer and provides important information, including product identification, hazardous ingredients, physical data, fire and explosion data, health hazard data, reactivity data, spill- or leak-cleanup and rectification procedures, and special protective and precaution information.

Agencies such as state departments of labor can often assess workplace exposures. Once a chemical in question is defined, physicians can obtain information regarding teratogenic, mutagenic, carcinogenic, and fetotoxic effects of various chemicals by using several resources (see the "Resources" section at the end of this article).

When assessing the exposure risk of chemicals and heavy metals, it is necessary to accurately quantify the level of exposure. This can be done with modern industrial hygiene techniques that can calculate the dose of exposure based on formulas that include the concentration, route, and duration of exposure. The calculated exposure dose can then be compared with known published standards of exposure limits to provide a clinical risk assessment.

Workplace exposure limits are generally established and enforced by the Occupational Safety and Health Administration, which is advised by the National Institute for Occupational Safety and Health. These exposure limits are known as permissible exposure limits and threshold limit values. Unfortunately, adequate human studies of reproductive and developmental toxicity are often lacking. In fact, many of these established limits were set to protect against specific health effects such as respiratory symptoms, eye irritation, and cancer and not developmental and reproductive effects. When human data on developmental and reproductive effects are lacking, risk is assessed by interpolating data from studies of animals using established "no-observed-adverse-effect levels," which are determined in the most sensitive animal species tested. Although this is obviously an imperfect situation, it can provide some insight into the possible risks and concerns of a chemical exposure.[13]

Based on these available resources, a physician can better synthesize an exposure risk and provide the appropriate guidance to a patient. Helpful interventions may include a temporary job change, reducing the use of hazardous materials, applying personal protective equipment, or absenting from work when alternatives do not seem feasible.

Physical Exertion and Pregnancy

The effects of physical exertion on the reproductive health of pregnant women have been studied. Unfortunately, many study results are difficult to interpret and apply clinically. Most studies have used preterm birth and low birth weight as common end points, thus requiring a large study population to render statistically significant results. Further, when significant associations have been determined, clinical significance is often lacking (that is, what is the clinical significance of preterm birth at 37 weeks of gestation?).

Results among studies are often conflicting, and some have actually shown a decreased incidence of adverse pregnancy outcomes among working women. Confounding factors must be considered, including

TABLE 1.—*American Medical Association's Guidelines of Physical Activity During Pregnancy**

Activity Level	*Week of Gestation*
Secretarial and light clerical	40
Professional and managerial	40
Sitting and light tasks	
Prolonged (>4 hr)	40
Intermittent	40
Standing	
Prolonged (>4 hr)	24
Intermittent	
>30 min/hr	32
<30 min/hr	40
Stooping and bending below knee level	
Repetitive (>10 ×/hr)	20
Intermittent	
(<10>2 ×/hr)	28
(<2 ×/hr)	40
Climbing	
Vertical ladders and poles	
Repetitive (≥4 ×/8-hr shift)	20
Intermittent (<4 ×/8-hr shift)	28
Stairs	
Repetitive (≥4 ×/8-hr shift)	28
Intermittent (<4 ×/8-hr shift)	40
Lifting	
Repetitive	
>23 kg (51 lb)	20
<23 kg >11 kg (24 lb)	24
<11 kg	40
Intermittent	
>23 kg	30
<14 kg (31 lb) >11 kg	40
<11 kg	40

*From the American Medical Association's Council on Scientific Affairs.[40]

recall bias and the socioeconomic differences between working and unemployed women. Changes in work patterns resulting from pregnancy outcomes can lead to selection bias. For example, women with live-born children might choose to stop working, whereas those who have spontaneous abortions may tend to remain at work. In addition, those women who have live-born children with birth defects or other serious health concerns might be the most likely to quit work.

In a recent case-control study of US nurses (1,470 pregnancies, 210 preterm births defined as <37 weeks' gestation, and 1,260 births delivered at >37 weeks), prolonged standing for four hours or more per shift was associated with a preterm birth.[30] Other studies have also demonstrated an association of preterm birth, low birth weight, or spontaneous abortion with prolonged standing, lifting, and physical exertion.[31–37] Not all studies, however, showed these increased risks.[38,39] Possible mechanisms to the described outcomes include decreased venous return with standing and increased abdominal pressure with lifting and heavy exertion, which may compromise fetal circulation.

Realizing the difficulties of drawing conclusive results from past studies, the American Medical Association, through its Council of Scientific Affairs, has published guidelines for the continuation of work during pregnancy (Table 1).[40] These guidelines assume that a woman is healthy and that the pregnancy is otherwise uncomplicated. Physicians who counsel pregnant employees should be familiar with these guidelines when considering work restrictions.

Physicians must accurately define the level of physical exertion encountered at the workplace of a pregnant woman. If the employee is unable to accurately describe her activities at work, information may be obtained by speaking directly with the employer and reviewing the written job description. In some cases, the use of an experienced ergonomist to evaluate the work situation and provide an accurate assessment may be appropriate.

The occupational climate, including exposure to moisture, noise, temperature, and vibration, may pose additional risks. Mamelle and colleagues studied temperature, moisture, noise, and vibration and found an increased risk of preterm birth when two or more of these factors were present.[32]

The evaluation of a pregnant worker must be individually tailored. Physicians should intervene when a pregnant worker's level of activity is excessive. Many workplace modifications can usually be made, especially in the later stages of pregnancy, to enable the worker to continue employment safely. This requires direct communication among the physician, employer, and the pregnant worker. Modification can include special safety training, lighter duty, reducing the number of hours worked, and allowing more frequent rest periods. A temporary job reassignment might be an additional option.

Infectious Exposures

Infectious exposures are also a special concern among pregnant workers. Health care, school, and institutional workers are at the highest risk. Cytomegalovirus, parvovirus, rubella, and varicella are the more common viruses that pose considerable risk to a fetus through maternal transmission.[41] These viruses are generally transmitted through the respiratory route and therefore may represent possible occupational exposures.

Cytomegalovirus is usually transmitted through blood and sexual contact in adults but can also be transmitted through the respiratory and urinary tracts of children.[42] Fetal exposure may rarely cause cytomegalic inclusion disease but more commonly is associated with microcephaly, mental and motor disability, and sensorineural hearing loss. Intrauterine infection with cytomegalovirus has resulted in newborn manifestations of lethargy, respiratory distress, and seizures.[43–45]

Human parvovirus B19 is transmitted through respiratory secretions and causes erythema infectiosum or fifth disease among children. Maternal infection can

lead to fetal transmission and subsequent hydrops fetalis or erythroblastosis fetalis, severe hemolytic anemia with a fetal death rate of about 9%.[41,46] Women with serologic evidence of recent parvovirus B19 infection should undergo serial fetal ultrasonographic examinations. Ultrasonographic evidence of hydrops fetalis includes polyhydramnios, placentomegaly, pericardial or pleural effusions, and edema of the scalp and skin.[47] Intrauterine fetal transfusion may provide treatment of hydrops fetalis if detected by ultrasonography.[48]

In 1964, 30,000 cases of infant rubella were reported. Since 1979, only about 10 cases of rubella per year are reported in the United States. If maternal infection occurs during the first two months of gestation, there is a 40% to 60% chance of either spontaneous abortion or multiple congenital defects. The congenital rubella syndrome can include deafness, congenital heart disease, cataracts, glaucoma, and mental retardation.[41]

Infant mortality may approach 30% when mothers contract varicella infection five days before delivery or 48 hours postpartum.[41,49,50] Congenital manifestations of varicella are rare, but hypoplastic extremities, eye abnormalities, and central nervous system defects have been observed.[51]

When a potentially harmful exposure is identified, physicians should advise pregnant workers about taking necessary exposure precautions. This may mean a transfer to another position or even temporary work leave. Physicians should notify the US Department of Public Health to assist in controlling the spread of disease and preventing exposure to other pregnant workers.

Radiation and Electromagnetic Exposure

Pregnant women should avoid exposure to ionizing radiation and radioactive materials. Pregnant medical staff should avoid contact with patients being treated with radioactive isotopes—such as radioactive iodine for thyroid ablation therapy. Fetal exposure to even low levels of irradiation is a risk for mental deficiency, especially when exposure occurs during the 8th to the 15th week of gestation.[26,52,53] Studies also show a strong association between radiation exposure and a high risk of childhood leukemia and the development of other malignant lesions.[26] If alternative work or adequate protective measures for eliminating radiation exposure are not available, physicians should advise pregnant patients to terminate employment.

Initial reports of an increased risk of spontaneous abortion associated with video display terminals[54] and electromagnetic fields[55,56] precipitated further studies during the 1980s. Today, significant evidence of reproductive risks associated with electromagnetic fields and video display terminal exposure is lacking.[29,57–59]

Stress

Workplace psychosocial stress and fatigue are also possible reproductive risks. Of course, stress and fatigue are common in pregnancy regardless of the employment status, but the additional stress and fatigue caused by some work environments are of concern. The literature on this topic is difficult to interpret because studies have been mostly retrospective and severely limited by recall bias. Being a subjective disorder, psychological stress is difficult to quantify and is managed differently among people, further complicating research in this area. After constructing "an occupational fatigue score," Luke and colleagues[30] demonstrated a significant increased incidence of preterm birth with occupational fatigue.

Physicians' role should include identifying these factors and, when present, counseling patients on stress reduction and management. Many companies provide employees with confidential access to high-quality employee assistance providers; the use of these services can be a worthwhile intervention.

Summary

A multidisciplinary approach is required to assess the reproductive risks of pregnant workers. Physicians need to be aware of possible risks, identify and quantify such risks, and effectively counsel patients. Counseling may include alleviating unnecessary fears and intervening when risks are present to control a possible hazard. Physicians should familiarize themselves with the possible associated developmental and reproductive hazards unique to the local occupational climate to facilitate clinical risk assessment in their patients.

Hazardous reproductive exposures in the workplace can be reduced to provide safe employment for pregnant workers. Programs directed at informing employees of known hazards and reducing these risks by safe work practices, personal protective clothing, and a reduced use of toxic materials can be effective and easily practiced.

Physicians have a responsibility to both employers and patients to base decisions regarding the continuation of employment during pregnancy on scientific merit. This will result in better care of pregnant workers through awareness and prevention and greater productivity by reducing the number of lost workdays.

Future of Reproductive Health

Comprehensive exposure assessment requires up-to-date information and resources, a proper workplace evaluation that may be facilitated by ergonomists and occupational hygienists, and consultation with occupational medicine specialists for more complex cases.

In the future, hazards will need to be better-defined based on short- and long-term outcomes demonstrated in scientifically conducted studies. To this end, specific developmental effects on endocrine, cardiovascular, immune, neurologic, and pulmonary systems are being added to toxicology studies. Further, new multigenerational toxicology studies will provide a continuum of exposure risks on male and female reproduction.[60]

Resources

NIOSH Pocket Guide to Chemical Hazards
Publications Dissemination, DSDTT
National Institute for Occupational Safety and Health
4676 Columbia Parkway
Cincinnati, OH 45226
Telephone: (800) 35-NIOSH
Website: http://www.cdc.gov/niosh/homepage.html

Reproductive Toxicology Center (REPROTOX)
Columbia Hospital for Women Medical Center
2425 L St, NW
Washington, DC 20037
Telephone: (202) 293-5137
E-mail: reprotox@erols.com

TERAS
Department of Pathology
Brigham & Women's Hospital
75 Francis St
Boston, MA 02115
Telephone: (617) 732-6507
Fax: (617) 732-7513

TERIS
Teratogen Information System
Department of Pediatrics, TRIS WJ-10
University of Washington School of Medicine
Seattle, WA 98195

California Teratogen Information Service and Clinical Research Program
University of California, San Diego
Department of Pediatrics
Division of Dysmorphology and Teratology
225 Dickinson St, Rm 8446
San Diego, CA 92103-8447
Telephone: (619) 543-2131
Fax: (619) 291-0946

Occupational and Environmental Reproductive Hazards Center
University of Massachusetts Medical Center
Department of Obstetrics and Gynecology
55 Lake Ave N
Worcester, MA 01655
Telephone: (508) 856-2818
Fax: (508) 856-2965

REFERENCES

1. Pregnancy Discrimination Act of 1978, 92 Stat 2076, 42 USC §20003 (k)

2. Title VII of the Civil Rights Act of 1964, 42 USC §2000e et seq

3. Scialli A. Fetal protection policies in the United States. Semin Perinatol 1993; 17:50–57

4. International Union v Johnson Controls, 680 F Supp 309 (ED Wis 1988)

5. International Union v Johnson Controls, 886 F2d 871 (7th Cir 1989)

6. UAW v Johnson Controls, 59 USLW 4209 (1991)

7. Clauss C, Berzon M, Bertin J. Litigating reproductive and developmental health in the aftermath of UAW versus Johnson Controls. Environ Health Perspect 1993; 101(suppl 2):205–220

8. Saiki C, Gold E, Schenker M. Workplace policy on the hazards to reproductive health. Occup Med 1994; 9:541–549

9. Family and Medical Leave Act of 1993 (Pub L 103-3), 5 USC 6381-6387

10. Temporary Disability Insurance Law (chap 392, HRS), State of Hawaii Disability Compensation Division, Department of Labor and Industrial Relations; 1995

11. O'Brien J, Rosenwasser S. Counseling for occupational exposures and reproductive risks. Semin Perinatol 1993; 17:45–49

12. Paul M, Himmelstein J. Reproductive hazards in the workplace: what the practitioner needs to know about chemical exposures. Obstet Gynecol 1988; 71:921–938

13. Paul M. Occupational and environmental reproductive hazards. Baltimore (Md): Williams & Wilkins; 1992, pp 113–131

14. Tannenbaum T, Goldberg R. Exposure to anesthetic gases and reproductive outcome. J Occup Med 1985; 27:659–668

15. Buring J, Hennekens C, Mayrent S, Rosner B, Greenberg E, Colton T. Health experience of operating room personnel. Anesthesiology 1985; 62:325–330

16. Pharoah P, Alberman E, Doyle P, Chamberlain G. Outcome of pregnancy among women in anaesthetic practice. Lancet 1977; 1:34–36

17. Hemminki K, Mutanen P, Saloniemi I, Niemi M, Vainio H. Spontaneous abortion in hospital staff engaged in sterilizing instruments with chemical agents. Br Med J 1982; 285:1461–1463

18. Rom W. Effects of lead on the female and reproduction: a review. Mt Sinai J Med 1976; 43:542–552

19. McMichael A, Vimpani G, Robertson E, Baghurst P, Clark P. The Port Pirie Cohort Study: maternal blood lead and pregnancy outcome. J Epidemiol Community Health 1986; 40:18–25

20. Bellinger D, Leviton A, Waternaux C, Needleman H, Rabinowitz M. Longitudinal analysis of perinatal and postnatal lead exposure and early cognitive development. N Engl J Med 1987; 316:1037–1043

21. Needleman H, Rabinowitz M, Leviton A, Linn S, Schoenbaum S. The relationship between prenatal exposure to lead and congenital anomalies. JAMA 1984; 251:2956–2959

22. Bridbord K. Occupational lead exposure and women. Prev Med 1978; 7:311–321

23. Bellinger D, Leviton A, Needleman H, Rabinowitz M, Waternaux C. Low-level lead exposure and infant development in the first year. Neurobehav Toxicol Teratol 1986; 8:151–161

24. Ernhart C. A critical review of low-level prenatal lead exposure in the human. 2. Effects on the developing child. Reprod Toxicol 1992; 6:21–40

25. Koos B, Longo L. Mercury toxicity in the pregnant woman, fetus, and newborn infant. Am J Obstet Gynecol 1976; 126:390

26. Maxcy, Rosenau, Last. Public health and preventive medicine. 13th ed. San Mateo (Calif): Appleton & Lange; 1992, pp 403–558

27. Sullivan J, Krieger G. Hazardous materials toxicology: clinical principles of environmental health. Baltimore (Md): Williams & Wilkins; 1992

28. Schardein. Chemically induced birth defects. New York (NY): Marcel Dekker; 1993

29. Lidstrom IM. Pregnant women in the workplace. Semin Perinatol 1990; 14:329–333

30. Luke B, Mamelle N, Keith L, Munoz F, Minogue J, Papiernik E, Johnson T. The association between occupational factor and preterm birth: a United States nurses' study. Am J Obstet Gynecol 1995; 173:849–862

31. Colie C. Preterm labor and delivery in working women. Semin Perinatol 1993; 17:37–44

32. Mamelle N, Lauman B, Lazar P. Prematurity and occupational activity during pregnancy. Am J Epidemiol 1984; 119:309–322

33. Klebanoff M, Shiono P, Rheads G. Outcome of pregnancy in a national sample of resident physicians. N Engl J Med 1990; 323:1040–1045

34. Teitelman M, Welch C, Hellenbrand K, Bracken M. Effect of maternal work activity on preterm birth and low birth weight. Am J Epidemiol 1990; 131:104–113

35. Launer L, Villar J, Kestler E, de Onis M. The effect of maternal work on fetal growth and duration of pregnancy: a prospective study. Br J Obstet Gynaecol 1990; 97:62–70

36. McDonald A, McDonald J, Armstrong B, Cherry N, Nolin A, Robert D. Prematurity and work in pregnancy. Br J Ind Med 1988; 45:56–62

37. Florack E, Zielhurs G, Pellegrino J, Rolland R. Occupational physical activity and the occurrence of spontaneous abortion. Int J Epidemiol 1993; 22:878–884

38. Naeye R, Peters E. Working during pregnancy: effects on the fetus. Pediatrics 1982; 69:724–727

39. Berkowitz G, Kelsey J, Holford T, Berkowitz R. Physical activity and the risk of spontaneous preterm delivery. J Reprod Med 1983; 28:581–588

40. Council on Scientific Affairs (American Medical Association). Effects of pregnancy on work performance. JAMA 1984; 251:1995–1997

41. Mandell GL, Bennett JE, Dolin R, editors. Principles and practice of infectious diseases. 4th ed. New York (NY): Churchill Livingstone; 1995

42. Pass R, August A, Duvorsky M, Reynolds D. Cytomegalovirus infection in day care centers. N Engl J Med 1982; 307:477–479

43. Ahlfors K, Harris S, Ivarsson S, Svanberg L. Secondary maternal cytomegalovirus infection causing symptomatic congenital infection. N Engl J Med 1981; 305:284

44. Hanshaw J. Developmental abnormalities associated with congenital cytomegalovirus infection. In: Wollam DHM, editor. Advances in teratology. Vol 4. New York (NY): Academic Press; 1970

45. Ho M. Cytomegalovirus: biology and infection. 2nd ed. New York (NY): Plenum Publishing; 1991

46. Public Health Laboratory Service Working Party of Fifth Disease. Prospective study of human parvovirus B19 infection in pregnancy. Br Med J 1990; 300:1166–1170

47. Rodis J, Quinn D, Gary W, Anderson L, Rosengren S, Cartter M, et al. Management and outcomes of pregnancies complicated by human B19 parvovirus infections: a prospective study. Am J Obstet Gynecol 1990; 163:1168–1171

48. Schwarz T, Roggendorf M, Hottentrager B, et al. Human parvovirus B19 infection in pregnancy. Lancet 1988; 1:566–567

49. Brunell P. Fetal and neonatal varicella zoster infections. Semin Perinatol 1983; 7:47–56

50. Preblud S, Bregman D, Vernon L. Deaths from varicella in infants. Pediatr Infect Dis 1985; 4:503–507

51. Paryani S, Aruin A. Intrauterine infection with varicella zoster after maternal varicella. N Engl J Med 1986; 314:1542–1546

52. Dunn K, Yoshimaru H, Otake M, Annegers J, Schull W. Prenatal exposure to ionizing radiation and subsequent development of seizures. Am J Epidemiol 1990;131:114–123

53. Schull W. The status of somatic risk estimation. Proceedings of the 25th annual meeting of the National Council on Radiation Protection and Measurements, Bethesda, Md, 1990, Proc. No. 11:27–42

54. Goldhaber M, Rolen M, Hiatt A. The risk of miscarriage and birth defects among women who use visual display terminals during pregnancy. Am J Ind Med 1988; 13:695–706

55. Wertheimer N, Leeper E. Possible effects of electric blankets and heated waterbeds on fetal development. Bioelectromagnetics 1986; 7:13–22

56. Juutilainen J, Matilainen P, Saarikoski S, Laara E, Suonia S. Early pregnancy loss and exposure to 50-Hz magnetic fields. Bioelectromagnetics 1993; 14:229–236

57. McDonald A, McDonald J, Armstrong B, Cherry N, Nolan A, Robert D. Work with visual display units in pregnancy. Br J Ind Med 1988; 45:509–515

58. Schnorr T, Grajewski B, Hornung R, Thon M, Egeland G, Murray W, et al. Video display terminals and the risk of spontaneous abortion. N Engl J Med 1991; 324:727–733

59. Roman E, Beral V, Pelerin M, Hermon C. Spontaneous abortion and work with visual display units. Br J Ind Med 1992; 49:507–512

60. Golub M, Chernoff G. Issues in regulatory protection of reproductive health in the workplace. Occup Med 1994; 9:374–38